

OPTICAL COHERENCE TOMOGRAPHY IN THE EVALUATION OF ANTERIOR EYE INJURIES IN SPACEFLIGHT

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DISCLOSURE INFORMATION

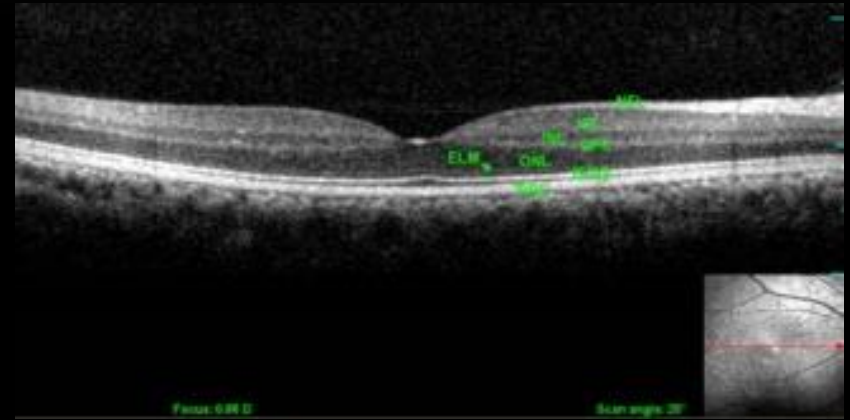
88TH ANNUAL SCIENTIFIC MEETING

DANYAL M FER MD

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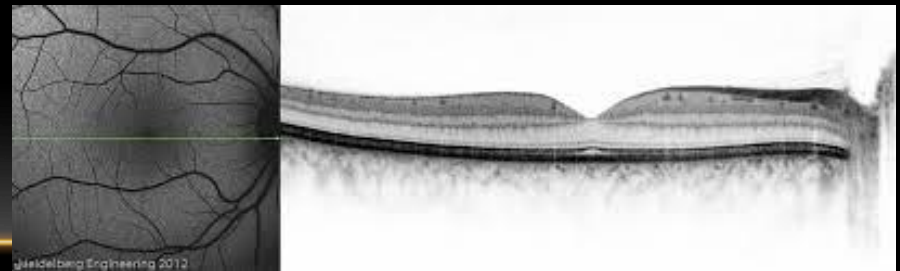
OPTICAL COHERENCE TOMOGRAPHY (OCT)

- Utilizes low-coherence interferometry
- Utilized in medical imaging
 - Retina
 - Coronary Vessels
- Key benefits
 - Live sub-surface 3D images up to 2mm
 - Instant imaging of tissue morphology
 - No preparation of the sample or subject
 - No ionizing radiation



CURRENT USE IN SPACEFLIGHT

- Currently on International Space Station
- Evaluating changes associated with Visual Impairment/Intracranial Pressure (VIIP) Syndrome
- Astronauts have 1.75 hours of preflight training
- Actual exams are completed with remote guidance from ground

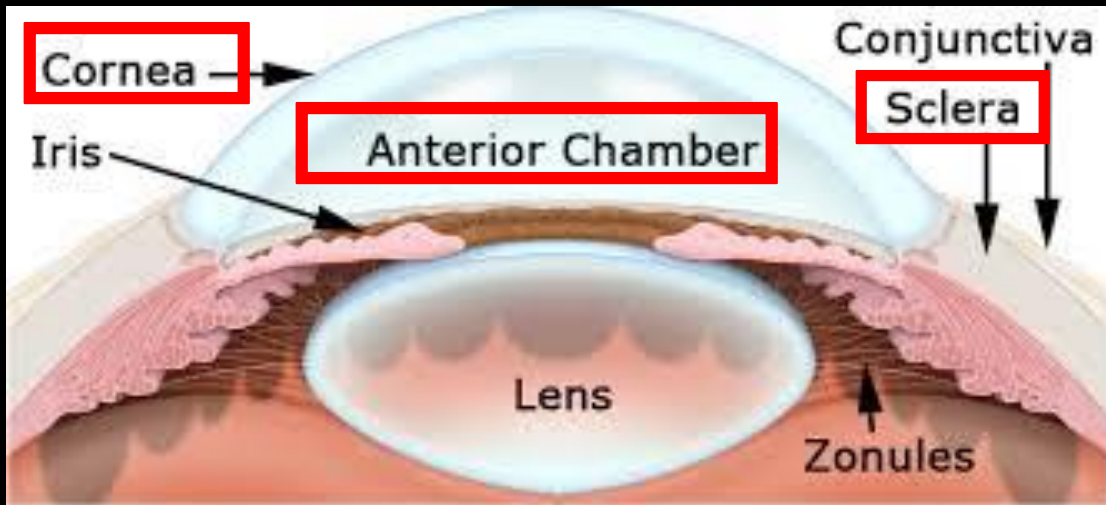


REMOTE GUIDANCE

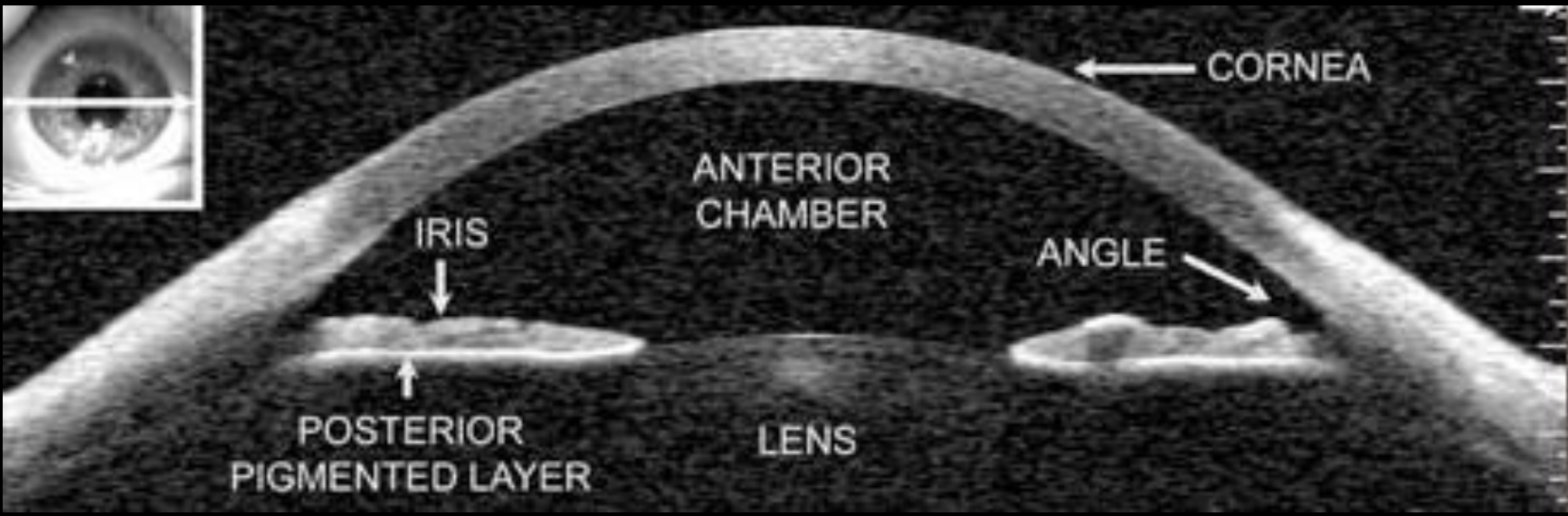
- Protoled method of expert guidance of novice users for complex processes
- Development of step-by-step instructions
 - Remote guider (RG)
 - Optometrists as Subject Matter Experts (SMEs)
 - Flight surgeon
- Implementation
 - Real-time teleconference between subject, operator, and ground team
 - RG, SME

ANTERIOR SEGMENT MODULE (ASM)

- Additional lens that allows imaging of...
 - Cornea
 - Sclera
 - Anterior angle/anterior chamber
- OCT is not the typical modality to look at these structures terrestrially



ANTERIOR STRUCTURES ON OCT



PURPOSE

- Develop a remote guider script to allow astronauts to utilize existing hardware on the ISS to be able to diagnose anterior eye pathologies.

METHODS

- Research
 - Evaluated existing OCT RG scripts for retinal applications
 - Evaluated device manufacturer's user manual
 - Consulted subject matter experts on device settings
- Hardware familiarization

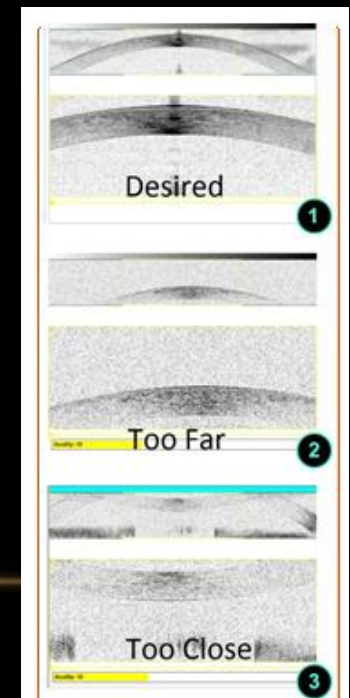
METHODS

- Creation
 - Converted instructions for ophthalmologist to instructions for layman
 - Refined instructions based on experience drawn from simulations for use in training novice remote guiders

▶ Move the camera slowly towards the patient's eye until the OCT image is displayed in the Sweet Spot ①. If the apex reflex is visible in the OCT image, the light beam is perpendicular to the cornea surface.

If the camera is too far away from the patient's eye, the cSLO image is out of focus and the OCT image is not in the Sweet Spot ②.

❖ *What you're looking for is an arched shape structure with the apex on top. Use the big knob to move the camera slowly towards the patient's eye until you are able to see a full "rainbow." You may have to disengage the slide to move the camera away from [Subject] far enough to get an acceptable image.*



RESULTS

- RG script for cornea exam
- Potential applications
 - Corneal abrasion
 - Corneal ulcer
 - Keratitis
 - Corneal foreign body
 - Tear film/dry eye evaluation

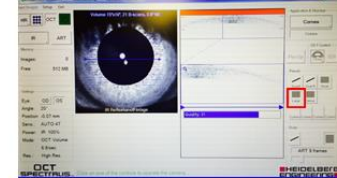
EXAMINATION OF THE CORNEA

Operator:

- ❖ Let's load the cornea application so we can start adjusting the camera.

If "Cornea" is not already selected in "Application & Structure":

- ❖ On the upper right side of the screen, click on the box labeled "Sclera" (or "Angle") and select "Cornea."
- ❖ On the middle right side of the screen is a section labeled "Preset." Click on the "Large" icon.



Subject:

- ❖ Now position your chin and forehead on the chin rest and look straight ahead. Your forehead must remain in contact with the hardware during testing.
- ❖ Reach around the camera arm and feel for the stage release. [Operator] can help you find it. Once you locate it, depress it and slide the camera until you can see a hazy red light in the center. It does not have to be in focus.
- ❖ Tweak your head and chin position slightly to get the red light as bright as you can make it. Let us know when you're there.

If unable to find red light:

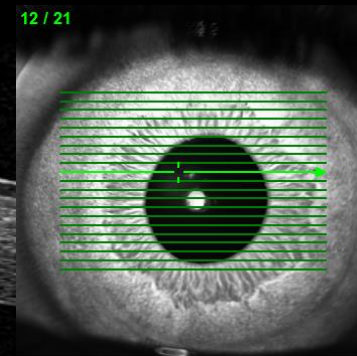
- ❖ [Subject], make sure your chin and forehead are straight on the chin rest and you're not rotated.
- ❖ [Operator], pull the black slide away from [Subject] and get a bright spot on the eye image.
 - "Bright spot" low: rotate chin rest grip counterclockwise to move chin rest up
 - "Bright spot" high: rotate chin rest grip away clockwise to move chin rest down

Once "bright spot" centered:

- ❖ [Operator], push the black slide back towards [Subject] to re-engage the ball detent.
- ❖ Now adjust the small knob to get the image centered.

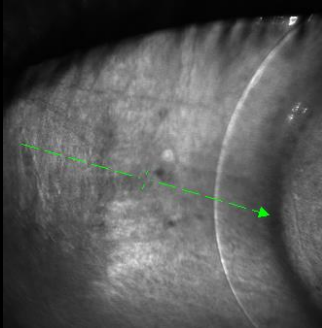
Aligning the Camera

- ❖ Ensure the black slide is pushed towards [Subject] until the ball detent is engaged
- ❖ If the lens is too close and touches [Subject]'s eye you may need to clean the lens before starting the examination
- ❖ Now use the adjustment knobs to center the eye in the IR Reflectance window. Adjust the small knob to move left or right, the middle knob to move up or down relative to the subject.
- ❖ Rotate the big knob towards the subject to move the camera to get an evenly illuminated IR reflectance window.



RESULTS

- RG script for sclera exam
- Potential applications
 - Scleritis
 - Episcleritis



EXAMINATION OF THE SCLERA

Operator:

- ❖ *Let's load the cornea application so we can start adjusting the camera.*

If "Sclera" is not already selected in "Application & Structure":

- ❖ *On the upper right side of the screen, click on the box labeled "Cornea" (or "Angle") and select "Sclera."*
- ❖ *On the middle right side of the screen is a section labeled "Preset." Click on the "Scan11" icon.*

Subject, if not previously done:

- ❖ *Make sure your eye patch is over the left eye [right eye second time].*
- ❖ *Now position your chin and forehead on the chin rest and look straight ahead. Your forehead must remain in contact with the hardware during testing.*
- ❖ *Depress the stage release and slide the camera to the right [left the second time]. Adjust it until you can see a hazy red light in the center. It does not have to be in focus.*

+ If unable to find red light:

- ❖ *[Subject], make sure your chin and forehead are straight on the chin rest and you're not rotated.*
- ❖ *[Operator], pull the black slide away from [Subject] and get a bright spot on the eye image.*
 - *"Bright spot" low: rotate chin rest grip counterclockwise to move chin rest up*
 - *"Bright spot" high: rotate chin rest grip away clockwise to move chin rest down*
- Once "bright spot" centered:
- ❖ *[Operator], push the black slide back towards [Subject] to re-engage the ball detent.*
- ❖ *Now adjust the small knob to get the image centered.*

❖ Blink naturally.

Aligning the Camera

- ❖ *Now use the adjustment knobs to center the eye in the IR Reflectance window. Adjust the small knob to move left or right, the middle knob to move up or down relative to the subject.*
- ❖ *Rotate the big knob towards the subject to move the camera to get an evenly illuminated IR reflectance window. You may have to disengage the slide to move the camera back far enough to get an acceptable image.*

RG: Be aware that the image will be overexposed for several seconds until the automatic image brightness control adjusts the correct illumination.

Subject:

- ❖ *Look [insert per RG instructions below].*

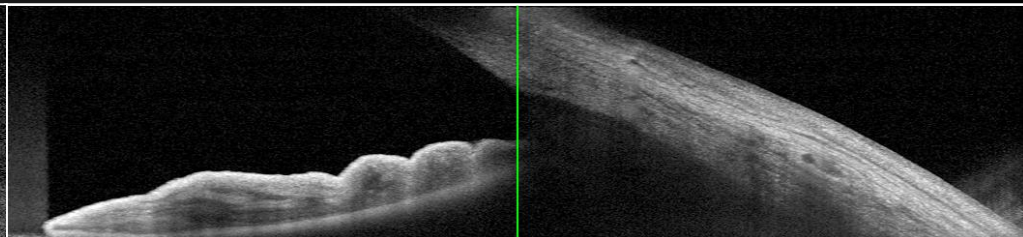
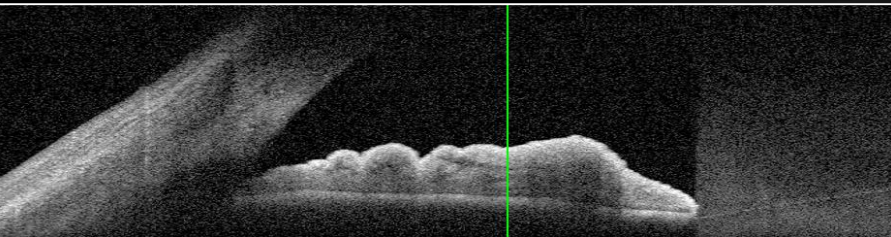
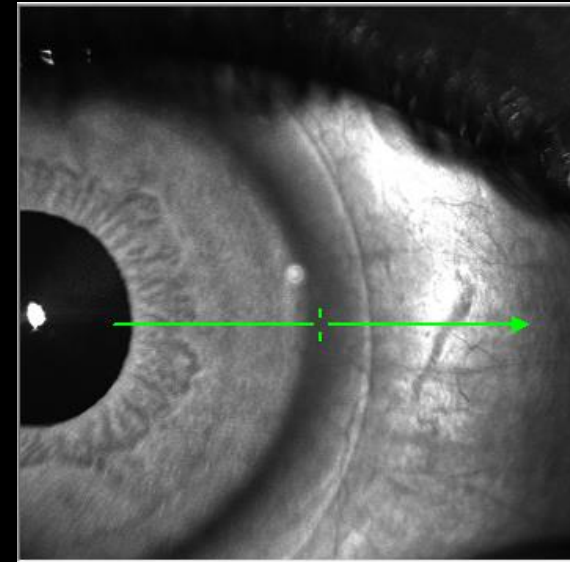
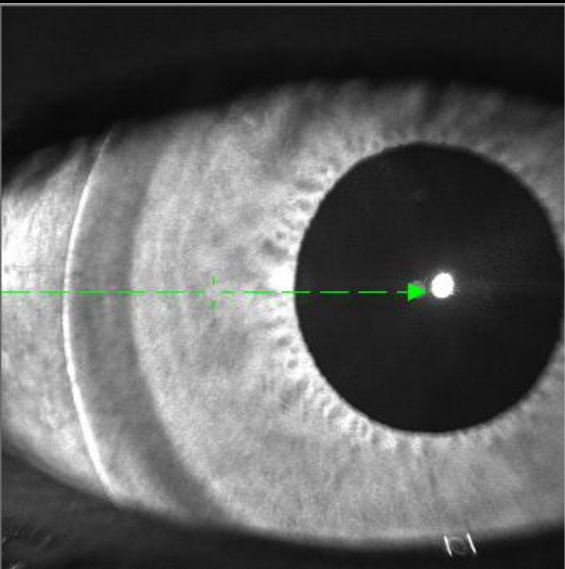
RG: If pathology is in

- lateral right eye "look TOWARDS your nose and pick a level object to focus on"*
- medial right eye "look AWAY from your nose and pick a level object to focus on"*
- lateral left eye "look TOWARDS your nose and pick a level object to focus on"*
- medial left eye "look AWAY from your nose and pick a level object to focus on"*

- ❖ *Now hold open your eye that is being examined*

RESULTS

- RG script for anterior angle
- Potential applications
 - Acute angle closure glaucoma
 - Uveitis
 - Hyphema
 - Hypopyon



DISCUSSION

- A remote guider script was developed for a completely new method of evaluation of anterior eye pathology on orbit
- Not intended for first-line evaluation of corneal injuries (would use standard fluorescein and cobalt blue light), but could be deployed to evaluate more serious injuries or those not responding to treatment
- Challenges
 - Providing proper education on where best images are acquired
 - Crewmembers are not trained on ASM use
 - Maintaining RG proficiency on the ground
- Moving forward
 - Considering an inflight demonstration of ASM to validate RG script

REFERENCES

- Hariharan, P. (2007). *Basics of Interferometry*. Elsevier Inc.
- Huang, D; Swanson, EA; Lin, CP; Schuman, JS; Stinson, WG; Chang, W; Hee, MR; Flotte, T et al. (1991). "Optical coherence tomography". *Science* **254** (5035): 1178–81.
- Heidelberg Engineering GmbH. *Spectralis Anterior Segment Module*. Heidelberg: Heidelberg Engineering, 2012. Print. Software Version 5.6.

QUESTIONS?
